IMPROVING THE MANAGER'S ABILITY
TO
IDENTIFY ALTERNATIVE TECHNOLOGIES

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THESIS

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TO
IDENTIFY ALTERNATIVE TECHNOLOGIES

by

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March 1980

Thesis Advisor: D.M. Rousseau

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Improving the Manager's Ability to Identify Alternative Technologies		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; March 1980
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Wayne Joseph Newton		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE March 1980
		13. NUMBER OF PAGES 95
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

technology
technology transfer
alternative technologies
Decision Support System (DSS)
technology transfer process
Federal technology transfer

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
(Page 1) S/N 0102-014-6601

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. (continued)

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IMPROVING THE MANAGER'S ABILITY TO IDENTIFY ALTERNATIVE TECHNOLOGIES

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN TELECOMMUNICATIONS SYSTEMS MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 1980

ABSTRACT

Planning is a principle function of management. A vital component of this planning process is the identification by management of alternative technologies. This paper addresses the task of improving the manager's ability to identify alternative technologies appropriate to the strategy, structure and process of the manager's organization. An analysis of the technology transfer milieu of the Federal Government is integrated with a conceptual model of the technology transfer process. This integration provides some real world examples of the subtle and complex factors which define the technology transfer process. A brief description of the manner in which these transfer factors could be conceptually utilized to characterize the organizational typology of an organization and act as inputs to a computer-assisted Decision Support System (DSS) is given. The information provided herein clearly indicates the organizational factors which a manager can manipulate to improve the identification of alternative technologies.

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I. INTRODUCTION

A. BACKGROUND

Planning is a principle function of management. The ideal of present day organizational planning is towards the identification and careful validation of an organizational need as the first step in a planning process which works backwards from the future to the present to see what organizational or technological alternatives now exist or could be developed to meet the need. Planning in this manner can be defined as the effort to visualize "the future as history." [1:268]

A vital component of this planning process for the mid-range and long range periods is the identification by management of "appropriate" alternative technologies for the production of a good or service. The manner in which an organization defines its product-market domain (strategy) and constructs mechanisms (structures and processes) such as distinct administrative or reward systems to pursue these strategies defines that which is an appropriate technology.

This paper will address itself to the task of improving the manager's ability to identify alternative technologies. Improvements to this capability will result in a closer adaptation of the organization to its environment and enhance its ability to produce a good or service in response to fluctuating supply and demand.

There are certain terms which need to be defined for the purposes of this study. These terms are:

<u>Technology</u> - the application of knowledge to perform work. [2:531]

<u>Technology Transfer</u> - stimulating or helping someone other than the research supporter to use the results of the research. [3:12] It is a planned and rational movement of technology. It must be distinguished from the more general process of diffusion: the historic <u>unplanned</u> movement of technical or social items from one user to another without any focused effort to actively transfer the particular item. [4:2]

<u>Technological Innovation</u> - an idea which is perceived by an individual to be a new method, means or capacity to perform a particular activity. [4:1]

<u>Research and Development</u> - in the United States this is defined as: [3:21]

1. Basic Research - an increase of knowledge or understanding in science by gaining a fuller knowledge or understanding of the subject under study.

2. Applied Research - the practical application of scientific knowledge or understanding for the purpose of meeting a recognized need.

3. Development - the systematic use of scientific knowledge and understanding directed toward the production of useful materials, devices, systems or methods including design and development of prototypes and processes. Development excludes quality control, routine production testing and production.

B. OBJECTIVES

There are three objectives to this paper:

1. To improve the ability of a manager to identify alternative technologies.

2. To provide a point of reference for the manager attempting to characterize the technology transfer environment of his or her own organization.

3. To identify the potential utility of a computer-assisted Decision Support System (DSS).

These three objectives support a larger purpose of this paper:

4. To illustrate the extent to which an understanding of the technology transfer process can improve the scope and adequacy of organizational planning.

C. METHODOLOGY

The objectives of this study were accomplished in four steps:

1. Step One

An analysis was made of: 1) the scope of the effort expended by Federal research and development enterprises to provide technology suited to the needs of those groups requiring technological assistance; and 2) the mechanisms whereby information concerning technology is distributed to potential users. The purpose of this analysis was to characterize the R&D agencies of the Federal Government as a source of information concerning technology.

2. Step Two

A conceptual model of the technology transfer process depicting the flow of information from a source to a user was identified to provide the framework for an analysis of the factors defining the process. This was done to delineate the elements affecting technology transfer and to provide a conceptual background for the mechanisms which have arisen in the Federal sector for affecting the transfer of technology. In this way the subtle and complex nature of the technology transfer process could be embodied in real world examples of transfer mechanisms and thereby enhance

the utilization (by managers who demand "all meat and no potatoes") of the concepts proffered in the model.

3. Step Three

A brief exposition of the manner in which the factors defining the technology transfer process could be utilized conceptually to characterize the typology of an organization and act as inputs to a Decision Support System was made. This was done to provide the manager - imbued at this point with knowledge about the mechanisms and the importance of the technology transfer process - with a recognition of the potential utility of a computer-assisted management tool which could produce a set of suggested information presentation techniques best suited to the manager's own type of organization.

4. Step Four

The material presented by the methodologies above and supported by the literature presented in the references clearly indicates the organizational factors which a manager can manipulate to improve his or her decision-making skills and in particular, improve the ability to identify appropriate alternative technologies when formulating mid-range and long range plans for an organization.

Several appendices to the text are included for clarity of certain systems or terms. Appendix A describes three large information services of the Federal Government. These are the National Technical Information Service (NTIS), the Smithsonian Service Information Exchange (SSIE) and the National Referral Center (NRC). Appendix B describes

the relationship of government patent policy and Federal research and development. Appendix C describes some excellent management criteria for effective innovation.

...for every knotty problem there is a solution - neat, simple and wrong.
H.L. Mencken

II. MAJOR FEDERAL GOVERNMENT KNOWLEDGE CREATION, DISTRIBUTION AND APPLICATION SYSTEMS

A. INTRODUCTION

Technology is defined here as the application of knowledge to perform work. The Federal Government has spent in the past and will spend into the foreseeable future an enormous sum of money on the creation of knowledge. However knowledge that is not applied towards a new method, means or capacity to perform a given activity is, in itself, of arguable monetary value. Many social and scientific problems have resisted with an unexpected tenacity both the folk-wisdom and the scientific solutions applied to solve them. Birth control, poverty, waste disposal, health and energy are examples of these problems. The increasing complexity of methodologies developed by both public and private organizations for defining and resolving problems has required an analytic and carefully determined investment of organizational resources into fundamental, multi-discipline research and development (R&D) enterprises.

The combined expenditures of Federal agencies on research and development totaled over 350 billion dollars in the period from 1940 to 1978. [3:15] The thirteen years since 1965 accounted for nearly two-thirds of that total outlay. Table 1 depicts estimated sources of funds for R&D by broad industry classes in 1980.

TABLE 1

ESTIMATED SOURCES OF FUNDS FOR R&D BY BROAD INDUSTRY CLASSES, 1980

(Millions of Current Dollars)

Industry Class	Federal Funds	Industry Funds	Total Funds	% Federal
Aerospace	8,564.8	2,501.5	10,966.3	78.1
Electrical Machinery and Communications	3,917.9	4,581.3	8,499.2	46.1
Machinery	778.9	5,501.3	6,280.2	12.4
Autos, Trucks & Parts & Other Transportation Equipment	509.1	4,925.1	5,434.2	9.4
Chemicals	406.2	3,950.9	4,357.1	9.3
Professional & Scientific Instruments	162.9	1,866.6	2,029.5	8.0
Petroleum Products	213.8	1,241.1	1,454.9	14.7
Rubber Products	283.0	461.0	744.0	38.0
Fabricated Metals & Ordnance	87.6	432.4	520.0	16.8
Food & Beverage	2.0	515.2	517.2	0.4
Paper	-0-	467.9	467.9	0.0
Stone, Clay & Glass	31.6	422.6	454.2	7.0
Nonferrous Metals	28.6	335.9	364.4	7.8
Iron & Steel	10.2	356.6	366.8	2.8
Other Manufacturing	6.1	307.3	313.4	1.9
Lumber & Furniture	-0-	163.5	163.5	0.0
Textile Mill Products & Apparel	1.0	97.5	98.5	1.0
Total Manufacturing	15,003.6	28,027.7	43,031.3	34.9
Non-Manufacturing	695.4	706.3	1,401.7	49.6
TOTAL	*15,699.0	28,734.0	44,433.0	35.3

Source: Engineering Careers Magazine, College Edition V.1 No. 1 Jan. 1980 p. 15

* This figure represents approximately one-half of the total budgeted R&D funding of all Federal agencies in 1980. [ref 7]

The sheer magnitude of the Federal research and development effort requires that both public and private sector managers understand the patterns of that spending and most importantly, the mechanisms which have been developed for communicating and transfering the results of that research and development from the research supporters to the potential end-users. A significant concern of this chapter is to identify the scope of the Federal research and development effort and the major Federal knowledge creation, distribution and application systems presently in operation. A recognition of the vast stockpile of potentially useful and innovative Government developed or sponsored technologies is vital to the manager tasked with producing a set of alternative technological solutions to a senior management validated organizational need.

B. THE SCOPE OF THE FEDERAL R&D EFFORT

"In the final analysis, federal R&D products are intended to benefit the citizens of the country; but in general the citizens are third or forth party recipients." [5:15] The evidence for this statement is rooted in the structure of the federal government's technology transfer efforts and the numerous private, state, and local organizations which are participants in these efforts. To understand why this structure has developed and the implications for the manager, one must examine the patterns of Federal research and development spending.

There are many hundreds of Federal research and development installations composed of laboratories, research centers or technical field stations located worldwide. These installations employ approximately 23 percent of the total number of scientists and engineers engaged in research and development in the United States. About 35 percent of the Federal Government's research and development expenditures are applied to the three major functional categories of Federal laboratories. [3:19] These laboratory classifications are: [3:19]

1. Special-mission laboratories: have missions which often require high technology, but they have no inherent requirement to work with state or local governments or private industry (Department of Defense and National Aeronautics and Space Administration make up the vast majority of these).

2. Civil-mission laboratories: have an inherent need to work closely with state, local and other Federal Government units, and in some cases the private sector, in order to implement their programs (examples: Department of Transportation; Department of Commerce; Environmental Protection agency; Department of Health, Education and Welfare; and Department of Agriculture).

3. Federally Funded Research and Development Centers (FFDRC's): are research and development performing or managing organizations exclusively or substantially financed by one or more Federal agencies and administered for them by industrial firms, universities, or nonprofit institutions. [An example of this is the Lawrence Livermore Laboratory. It is funded by several Federal agencies and administered by the University of California.]

   The FFRDC's sponsoring agency has direct access to the center's resources. Additionally, the sponsor typically approves proposed undertakings of major or significant research and development activities of the FFRDC for other organizations.

The remaining 65 percent of Federal research and development funds are used to contract out research and development

work to universities, private industry and nonprofit organizations. [3:19] The bulk of Federal research and development expenditures in the civilian sector are intended to produce technologies and products useable by someone else, as opposed to a hoped for "windfall" or "spin-off" technology from a Federal space or defense research effort. [6:73]

There does not exist within the Federal Budget a uniquely identifiable budget category entitled Research and Development. Instead, nearly all of the over 90 agencies within the Federal government submit their own research and development requests based upon an in-house assessment of missions and needs. The aggregate expenditure for research and development in a given annual Federal Budget is dependent upon the decision-making mechanism employed by each agency concerning their individual R&D requests. "Decisions on the size and nature of research and development programs are based on the way they support agency missions and not on the way research and development functional elements relate to one another within the total budget." [3:18] There are some Federal agencies which do not perform research and development for the major purpose of enhancing their own technology base. For example: [8:49]

> Technology transfer at the Energy Research and Develop-Administration (ERDA) is an inherent part of the basic fabric of the organization. Unlike many other Federal agencies, ERDA is not a consumer of the fruit of its own labors. Neither does it profit through the sales of its research. It exists for the purpose of research, development and demonstration of energy related technologies,

> and as its national plan proclaims, its major task is to create energy choices for the future.

In 1977 ERDA's role was subsumed under the aegis of the Department of Energy (DOE).

In broad perspective the agencies forming the Federal Government have been structured and programs have been established along functional lines. This has led to Federal organizations dealing almost exclusively with their functional counterpart organizations at the state and/or local levels. This functional agency linearity has been described as "picket fence federalism." [5:16]

The need for solutions to problems which do not recognize functional boundaries has considerably complicated the efforts of planners and managers of general purpose government organizations to identify the appropriate technologies to which they can apply analytical planning strategems. In response to the demands of general purpose state/local officials for more efficient and effective Federal technology transfer methods several types of technology transfer programs have been developed. Examples of these programs will be given later in this chapter.

There are policy guidance and legislative indications that the Federal Government is attempting to restructure the technological milieu in which it has historically operated. The implementation of the Office of Management and Budget (OMB) Circular A-109 throughout the Federal Government is an example. This Circular requires in part that Federal agencies, when acquiring major systems, will:

- Express needs and program objectives in mission terms and not equipment terms to encourage innovation and competition in creating, exploring, and developing alternative system design concepts. [9:3]

An effect of A-109 then is to force the identification and articulation of mission deficiencies by each Federal agency while changing the role of the Federal laboratories from technology/hardware advocates to maintainers of the technology base and participants in the evaluation of system alternatives. This shift in orientation from a <u>technology-push</u> to a <u>needs-pull</u> perspective is particularly important to the Department of Defense which is the largest single recipient of Federal research and development funds. To comply with Circular A-109 all Federal agencies must reorient their planning strategems to respond to validated needs.

Another indication of Federal reorientation to the mechanisms of technology transfer is the National Science and Technology Policy, Organization, and Priorities Act of 1976. [3:63] This act created the Office of Science and Technology Policy (OSTP) in the Executive Office of the President. The OSTP is an advisory office to the President whose duties include the following: [3:63-64

1. Gather, analyze, and interpret timely and authoritative information concerning significant developments and trends in science and technology.

2. Utilize to the fullest extent possible, the services, personnel, equipment, facilities, and information... of public and private agencies and organizations, and individuals in order to avoid duplication of effort and expense.

Two policy advising groups were created within the OSTP. The Intergovernmental Science, Engineering and Technology

Advisory Panel and the Federal Coordinating Council for Science, Engineering and Technology. Some of their respective objectives are to:

- Advise and assist the Director [OSTP] in identifying and fostering policies to facilitate the transfer and utilization of research and development results so as to maximize their application to civilian needs. [3:64]

- Achieve more effective utilization of the scientific, engineering and technological resources and facilities of Federal agencies, including the elimination of unwarranted duplication. [3:64]

This paper will not discuss the effectiveness of the OSTP, OMB Circular A-109, or Congressional Committee investigation of Federal efforts to encourage the utilization of research and development outputs. [10] Instead this discussion delineates the Federal Government's recognition that there exists a lag between intergovernmental use, on all levels, of technology developed by its own departments and agencies and between the Federal government and state/local agencies.

There are several significant factors in the Federal Government's perception of what is necessary to aid not only in the identification of alternative technologies to a given problem but to ensure the conversion of a given technology to a useful product. These factors are: [5:18]

1. The technical community's awareness of the user communities needs and desires.

2. The technical knowledge and sophistication of the user community.

3. The technical knowledge and sophistication of the supplier community.

4. The extent of Federal program coordination.

5. The risk aversion environment.

6. The extent of market disaggregation.

The first four factors are of greatest concern to this paper.

In the first factor, the technical community's awareness of the user community's needs and desires implies that the likelihood of a research and development output being utilized in a different sector of society is highly dependent upon involving the potential end-user in the conceptual stage of development.

The second factor identifies the importance of the technical knowledge and sophistication of the potential end-user. Not every "target group" for a new technology has the requisite training or involvement in the technical community to identify the potential utility of a research and development laboratory output. This factor will be discussed in greater detail in the next chapter because the mechanisms by which planners/managers are made aware of the diverse types of technology available to them is the central concern of this paper.

Socio-economic considerations play a dominant role in the third factor; the technical knowledge and sophistication of the supplier community. Those organizations which are not technological "Prospectors" approach the creation, utilization and development of a new technology in widely divergent manners. The use of the term "Prospector" as a description of an organizational strategy, structure and process for the internal utilization and external transfer

of technology is taken from a typology of organizational adaptation developed by Miles et al in 1977. [18:546]

This organizational adaptation model states that: [11:553]

> ...the Prospector's choice of products and markets is not limited to those which fall within the range of the organization's present technological capability. The Prospector's technology is contingent upon both the organizations current and future product mix: entreprenurial activities always have primacy, and appropriate technologies are not selected or developed until late in the process of product development. Therefore, the Prospector's overall engineering problem is how to avoid long term committments to a single type of technological process, and the organization usually does so by creating multiple, prototypical technologies which have a low degree of routinization and mechanization.

Thus the strategy by which an organization defines its product-market domain, be it typified as that of a "Prospector" (or "Defender," "Analyzer," or "Reactor") as Miles et al have proposed, predetermines the level of technical knowledge and sophistication an organization will supply to its own operations and to the community via the socio-political or market mechanism.

Rousseau notes that: [2:531-540]

> (m)odern technology is an organizational phenomenon, both an outgrowth and a cause of the development of complex organizations. [Technology]...is shaped by the needs of organizations to provide their environments with a product or service in exchange for capital, fuel, and other resources. It in turn shapes the effectiveness of the organization and the responses of its members.

Transforming a promising technical possibility into a marketable reality is most often a very expensive and time consuming proposition. Development tends to be a much more expensive activity than invention. [12:51] Under idealized (i.e. academically pure) conditions the firm

which has:

- a significant but not dominant share of the market
- an established research and development department
- given consideration to only a single new product

will elect to develop a new technology or product when the total time for such development is the point on the firm's planning time-horizon where the slope of the firm's expected cost/time trade-off function equals the slope of the firm's relative benefits function. On a profit-maximizing assumption, the firm will apply the familiar marginal criteria. Therefore the marginal cost of accelerating development will equal the marginal discounted surplus of sales revenue over production and distribution costs as a result of the shortened development period. [12:79-80]

The above economic conceptualization does not accurately reflect the real world market structure but does point out that if there is little chance of investment recovery within a near-term period a firm may elect to "stick with what we know best" and attempt an application of a research and development output on a more propitious occasion. Although the public sector research and development organization is not usually a profit-maximizer it typically is a cost-minimizer and many of the same considerations apply.

The point of this discussion is that the technical knowledge and sophistication of the supplier community can be influenced not only by the perception that the customer is not interested in anything new but also by the powerful forces of the marketplace.

The fourth factor of concern is that of the extent of Federal program coordination. It is easy to recognize the suboptimal returns to an agency which supports the research, development and implementation of a new technology if that technology is incompatible with another agency's objectives or regulations. A classic Federal example is supporting the "War on Cancer" while providing price supports and cultivation expertise to tobacco growers. The planner/manager engaged in identifying alternative technologies must be aware of Federal agency cross-program relationships, and this information must be provided by the same agencies. This type of program coordination is in its infancy within the Federal Government, especially in the case of the Federal laboratories which are accountable to many agencies and lack a formal integrating management system. [3:20]

C. FEDERAL INFORMATION DISTRIBUTION AND TECHNOLOGY TRANSFER SYSTEMS

To succinctly define the mechanisms, approaches and projects undertaken by the Federal Government to provide its varied constituencies with the knowledge purchased through taxation of those constituencies is a difficult task. It is made even more difficult by the lack of general knowledge concerning just what is necessary to implement the planned and rational movement of technology from sources or suppliers to potential end-users. Several major studies have attempted to define the "actors" in this process. [13,14]

In the following section the major types of technology transfer mechanisms operating throughout the Federal sector will be delineated. [5:21]

1. Research and Development Projects

The extremely broad research base of the Federal special-mission, civil-mission and funded research and development centers is considerably augmented by the research contracts awarded to universities, private corporations, other business enterprises and nonprofit organizations. As an agent in the transfer of technology the research and development programs themselves contribute to the delivery process. Many Federal research and development needs are contracted out to private industry and act as contributors to the technical expertise of the actual (and potential) suppliers of technology/products. State and local organizations also receive Federal awards for research and development projects and this work substantially contributes to upgrading their technical expertise. However, the total funding for research and development for all states is only about 1 percent of the Federal expenditures for R&D. [3:36] It is not unusual for the Federal Government to contribute more funds to the states for research and development than the states themselves expend for that same purpose. [3:36]

Civil-mission laboratories are intended to work in the civilian (non-federal) area. The assets of these laboratories are intended to be applied so as to produce the greatest benefits to the country. These benefits are

determined by a prioritized assessment of regional goals. To encourage optimal resource allocation (as seen from the perspective of a Federal agency) and to avoid duplication of work the civil-mission laboratories derive their research requests by a prioritization methodology. This method begins by soliciting R&D requests from governors, mayors, and state/local officials. These inputs are directed to representatives from the various civil-mission agencies who in turn are members of one of the ten Federal Regional Councils. The councils themselves each manage a Federal Administrative Region. The inputs from the councils are prioritized at the national level by the sponsoring agencies of the civil-mission laboratories and research and development work is then apportioned to the appropriate laboratories on the basis of urgency, cost/benefit evaluation and budget constraints. This prioritization scheme is called the Outreach Program. [3:37]

Other public interest organizations also input their local research and development needs to the Federal Government. Examples of such groups are Public Technology, Incorporated and the Urban Consortium for Technology Initiatives. [3:39] The desired effect of this whole effort is to produce technology which can be utilized to solve the validated needs of the state and local governments. The real success of these programs will be measured by the extent to which the technology transfer process is a cooperative, person-to-person effort. It is the nature of the human animal to accept and incorporate most readily

the information obtained from direct human contact. The importance of the person-to-person interface in the transfer of technology will be elucidated later in this paper.

The special-mission laboratories are mainly operated by the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD). These laboratories do attempt to utilize their technical resources for the benefit of other government agencies and the private sector but they are limited by their national security mission. The nature of this mission stipulates that Federal resources in the form of the special-mission laboratories will not be used to perform research and development work outside the scope of the security mission. [3:42-44]

The Federally Funded Research and Development Centers are able and willing to support state, local and private sector R&D projects as long as the FFRDC's are careful not to compete with private industry in the private sector. [3:45]

NASA and DOE are examples of large public agencies with significant R&D responsibilities. The technology transfer program developed by NASA for civilian applications has been highly publicized and will not be detailed here. [6:73-84] The role of the DOE includes not only ERDA's former responsibilities but others as well such as: the marketing of Federal power resources, energy conservation, the nuclear weapons program, the regulation of energy production and use, pricing and allocation, and the management of a central energy data collection and analysis program. [15]

2. Field Organizations and Direct Assistance

One of the major results of research into the technology transfer process has been the recognition that it is a "people process." [3:12] Field organizations are semi-independent detachments of the larger laboratories and research centers located so as to be closer to the target groups of the R&D organizations. They are a very effective method of providing a face-to-face presentation of a new technology. [5:20] A prime example because of its undeniable success is the Agricultural Extension Service. [14:XVI] Farm productivity increases resulting from this type of program have been well documented. [14:XII] Field organizations and direct assistance programs yield their greatest benefits by developing the technical community's awareness of the user community's needs and developing the user community's own technical expertise.

3. Tailored Documents, Seminars, and Workshops

For many years the diverse agencies of the Federal Government based their technology transfer efforts and mission "on conventional wisdom and intuitive judgement as to how the process ought to occur rather than on empirical knowledge or research on how it actually occurs." [14:X] The most pervasive and highly developed instrument of this conventional wisdom has been the system by which research reports are distributed. Most Federal agencies have tended "to interpret their technology transfer mission in terms of documentation and formal information dissemination" and "assumed that information which was primarily applications-

oriented would be handled more or less automatically through commercial channels once the scientific information was properly documented and disseminated." [14:X] Research on those people who "apply knowledge to perform work," or technologists, indicates that publication in general "occupies a position of less importance than it does in science where it serves to document the end product and establish priority." [13:40]

Personal contact is the primary means to convey usable information about a technology. The "technologist publishes less and devotes less time to reading than do scientists." [13:45] As Allen notes: "The names of Wilbur and Orville Wright are not remembered because they published papers." [13:40] It has been within the last ten years that it has been recognized that "standard" research reports do not meet the needs of suppliers, operators, planners, managers, and policy makers in transfering and converting a technology into a final product. [5:21] The development of data bases which are rapidly accessible by a computer has allowed for the "tailoring" of research documents to a specific user community. The Federal Government has a number of personnel and offices tasked with the technology transfer function and which extensively utilize computer assisted access to the research reports data base. Appendix A describes three of the major efforts, the National Technical Information Service (NTIS), the Smithsonian Science Information Exchange (SSIE), and the National Referral Center (NRC).

Of particular value to the planner/manager are the Information Analysis Centers (IAC's) sponsored by the major Federal R&D agencies. Quoted below is a description of the IAC's function as stated within a report bibliography from the Defense Technical Information Center (DTIC); which is itself a computerized DOD data base.

> ...information analysis centers are responsible for collecting, storing, reviewing, evaluating, synthesizing, repackaging, and disseminating authoritative scientific and technical information in formats most useful to the scientists, engineers, and technicians they support. The centers are highly selective with regard to the quality of information they disseminate. From the literature acquired, they extract and evaluate information pertinent to the needs of their users. This evaluated information is synthesized and packaged in a variety of useful formats. The centers generally offer the following categories of products/services: technical inquiry service; bibliographic inquiry service; scientific and engineering reference works; state-of-the-art reports; critical reviews and technology assessments; and current awareness bulletins. For additional information on specific centers services, you are invited to write or call the center of interest to you.

For information that is classified an appropriate security clearance is required.

Another quite different data base is under development by the Federal Laboratory Consortium for Technology Transfer. "It is a data base of, successful technology transfers. The technology may be in the form of things, ideas, or processes, however, it must have moved from the source to a user. It seems obvious that once a technology base has been used (an innovation), then there is a much greater likelihood that it will be used again. This new data base which contains only successful technology transfers is named TECTRA." [16:5]

Seminars and workshops are highly effective methods to disseminate technology. [5:22] They could be made even more effective by applying new instructional technology advances to their organizational format and by encouraging an organization to provide "in-house" incentives to employees which attend them. [17] Tailored documents, seminars, and workshops are most effective in developing the technical expertise of both the user and the supplier.

4. Training and Personnel Exchanges

The Intergovernmental Personnel Act of 1970 (IPA) provided for interchange assignments between Federal agencies, state and local government and/or universities. An example of the use of the IPA in promoting technology transfer was the formation of the Federal Laboratory Consortium for Technology Transfer (mentioned previously). [3:48, 5:22] The consortium is an informal organization open to all Federal agencies whose purpose is to increase the use of member laboratory's technical expertise and research outputs to help solve problems facing all levels of the Federal government and private industry. The Consortium and the IPA also are discussed in the section of this paper entitled, "Interagency Programs/Activities." Training and personnel exchanges "allow state and local government employees to attend courses, primarily targeted at federal employees, which are relevent to their needs." [5:22] This mechanism is particularly aimed at developing the technical expertise of potential users.

5. <u>Special Surveys</u>

Special surveys are technology transfer mechanisms designed to "specifically address the needs of the non-federal government and industry clients; specific information on needs and format requirements can be compiled on a program specific basis. This can be done through mail surveys, through scheduled planning meetings and other mechanisms which provide for a formal input." [5:22] Survey in this context means to determine via specific user recommendations obtained from questionaire and conversation the methods best suited to facilitate the exchange of information concerning technology. Special surveys are most effective in developing the technical community's awareness of the user's needs.

6. <u>Special Federal/User Mechanisms</u>

Special mechanisms are used to implement technology transfer by: [5:22]

1. Assuring direct involvement of state and local policy making levels with Federal policymakers.

2. Assuring that both needs aggregation and dissemination can be conducted using the same mechanism: a closed loop with feedback is then established.

3. Encouraging the use of a general-purpose organization which allows a sensitivity to cross-program impacts and resource requirements which no single channel can match.

Examples of these special mechanisms are the Urban Consortium for Technology Initiatives and the National Conference of State Legislatures (NCSL). The Urban Consortium consists of the 27 largest cities and six major urban countries of the nation, working together to develop R&D needs which

can be communicated to the Federal Government and private industry. The Urban Consortium is administratively handled for the cities/counties by Public Technology, Incorporated (mentioned previously). [3:39] The NCSL is supported by five federal agencies and has its own "information brokerage" system, the Model Interstate Scientific and Technical Information Clearinghouse (MISTIC). [5:22]

Other special mechanisms which are useful for bringing specialized people together in flexible groups for as long as a particular need exists are temporary project, product, or problem teams and matrix organizations. Temporary teams are groups of independent specialists brought together as necessary to accomplish a mission, but for no longer. Matrix organizations are most common in: [1:421]

> ...technical organizations in which many specialists such as scientists and engineers are employed to work on sophisticated projects or programs. The specialists are assigned to functional departments until they are needed on projects. Then they are temporarily transferred to a program manager until the project is completed or their contribution is no longer required.

The organizational chart for the arrangement quoted above resembles mathematical matrices, thus the term "matrix" organizations.

Another special federal/user mechanism which will not be specifically addressed here but is included as Appendix B is the Federal Patent System. The Patent System is intended to encourage invention and innovation. Appendix B outlines the relationship of patents to Federal R&D efforts.

These special mechanisms are most effective in developing the technical community's awareness of user needs, developing the technical expertise of the user and aggregating the market for usable technologies.

7. Demonstration Programs

Door-to-door salesmen long ago realized the efficacy of demonstrating a new technology or product while in the potential user's own environment. For the agencies of the Federal government: "One of the best methods of proving the applicability of new technology and reducing apparent risks is to fund tests of these new technologies in an operational environment. The demonstrations can either be specific tests of newly evolved technical, managerial or operational improvements or can attempt to integrate proven technologies on a scale beyond that initially attractive to most localities." [5:23] Demonstration programs aid in technology transfer by helping to alleviate risk and by developing the technical expertise of the user.

8. Information Services

There are over 2000 data bases that index and/or store technical information in the United States today. Several commercial organizations have developed systems that integrate access to these data bases so that it is possible to search many of the data bases through a single access point. [16:5] Many agencies within the Federal sector have also developed such systems along with their routinely distributed circulars and abstracts. For example, the Department of Transportation has developed a service

called TRIS-on-line (Transportation Research Information Services-on-line). This service is accessible from remote Teletype terminals via regular phone lines. [16:5] Commercial systems are also remotely accessible. Under most of these systems one has only to key in the subject matter of interest to obtain information on past and current research relevant to a given problem. Information services develop the technical expertise of the user and of the supplier.

9. Performance Specifications and Standards

Research has demonstrated that Government contract specifications can be a significant barrier to technology transfer between Federal agencies themselves and between Federal agencies and the outside world. [18] Government contract law basically defines specifications as: [19:68]

> ...the definitive or descriptive words identifying the subject matter [of a Government invitation, proposal or contract]. The use of specifications accomplishes two purposes; (1) the specification of requirements for an item, material, process or service, and its preservation, packaging, packing and marking; and (2) the establishment of criteria by which the Government can determine whether or not contract requirements have been met.

Design specifications, combined with their monitoring by competent personnel to prevent these Government mandated requirements from destroying innovation, are a potentially effective way of enhancing technology transfer. Another technique is to define specifications in terms of performance. Performance specifications: [19:69]

> ...express requirements in such terms as capacity, function, or operation of equipments. In this type of specification the details of design, fabrication, and internal structure are left to the option of the contractor,

except that certain features or parts may specifically be required.

Most Government contracts have both design and performance specifications within them. The intent here is to encourage greater use of performance specifications and reduce mandated design specifications. Performance specifications assist in realizing production economies in the public sector by helping to aggregate the market for new technological applications.

10. Interagency Programs and Activities

As indicated earlier, the Federal Laboratory Consortium for Technology Transfer is an example of an interagency mechanism for coordinating the myraid Federal agency research and development efforts. Each of the member laboratories has a technology transfer coordinator who acts as the point of contact for technology transfer matters at the laboratories. These representatives become familiar with a variety of technical resources beyond the confines of their own laboratories and are capable of functioning as a "technology broker" to state and local governments. [3:49] The laboratory representatives keep in contact with other persons interested in technology transfer by many mechanisms. One of these is the 1979 Technology Transfer Directory of People; a detailed list of persons interested in the process of technology transfer. [20]

Another interagency group of significance is the Committee on Domestic Technology Transfer chartered in 1974. Its objectives were delineated as follows: [5:24]

1. Exchange of information and experience on Federal agency efforts to disseminate technology.

2. Collect, compile, and disseminate Federal agency data on technology transfer programs, contact points, support resources for use by state/local governments and private industry.

3. Exchange of information on agency organization and experience for receiving user information on technology transfer needs and priorities.

This committee has been very active in pursuing these objectives. One of its several significant outputs has been the publishing of the Directory of Federal Technology Transfer. [5:24] This directory supplies specific and detailed information on a great many Federal agency's research and development efforts. It also specifically gives contact points, with names, through which a user can obtain information and assistance.

D. SUMMARY

The Federal Government has invested heavily in research and development. It will continue to do so in the future in response to such stresses as dwindling national resources, changing energy requirements, burgeoning foreign military and industrial technology, industrial pollution and declining productivity. While the U.S. R&D establishment is very large, it is fragmented and not under a single management or budgetary authority. Therein lies a principle problem for the planner/manager tasked with the identification of alternative technologies.

The Federal research and development effort has historically been one of technology-push wherein technical

solutions are developed by the research and development establishment without regard for the actual problems of the potential user community. The technological milieu in which the Federal laboratories have operated is changing as government agencies respond to the needs-pull requirements of their client or "target" communities and to the increasingly strident demands of the general-purpose state/local government managers. A great deal of effort is being made on the Federal level to study the actual mechanisms by which technology is transferred from suppliers to end users. Federal research reports are being distributed from increasingly centralized facilities designed to utilize common data bases. Research results are being systematically tailored to specific users to improve the utilization of research results. Some efforts are being made in the Federal sector to enhance the transfer of technology by person-to-person communication and demonstration.

The mechanisms for technology transfer which have arisen in the Federal sector have done so in response to perceived or actual needs of the users. But the needs of the users have themselves arisen from definable factors operating within each user organization. The relationship of these factors to the technology transfer mechanisms of the Federal sector will be discussed in the next chapter.

III. FACTORS WHICH AFFECT A MANAGER'S ABILITY TO IDENTIFY ALTERNATIVE TECHNOLOGIES

A. INTRODUCTION

In the previous chapter the Federal Government was identified and examined as a very large and diverse establishemnt which is an accessible source of knowledge and technology for organizations seeking to solve both esoteric and utilitarian problems. It certainly is not the only potential source of information concerning technology. Private organizations also expend a great deal of money and energy on the creation and application of knowledge as indicated by the R&D funding levels of Table 1. However economic and organizational imperatives arising from competition, the profit motive and the desire to remain in business compel many private firms to view a new technology as "proprietary" i.e. private knowledge.

Every organization, public or private, has come to realize that technology is a crucial source of prosperity in today's complex and interdependent world. Yet when compared to the highly developed analytical techniques available for assessing financing, marketing and production, the techniques available for assessing the flow of information concerning technology within an organization are rudimentary.

This chapter will examine a model which describes the manner in which inputs from sources of knowledge are

buffered in an organization by procedural and human behavioral factors. These factors, if recognized and addressed can potentially be manipulated through managerial skill and energy to enhance the transfer of technology. An understanding of the mechanisms by which information is buffered in an organization can allow the manager to identify, create and utilize the information channels which best meet his technical information needs. In this way organizational planning achieves greater flexibility because alternative methods, means or capacities to perform a given activity can be identified and evaluated.

B. A CONCEPTUAL MODEL FOR ANALYSIS

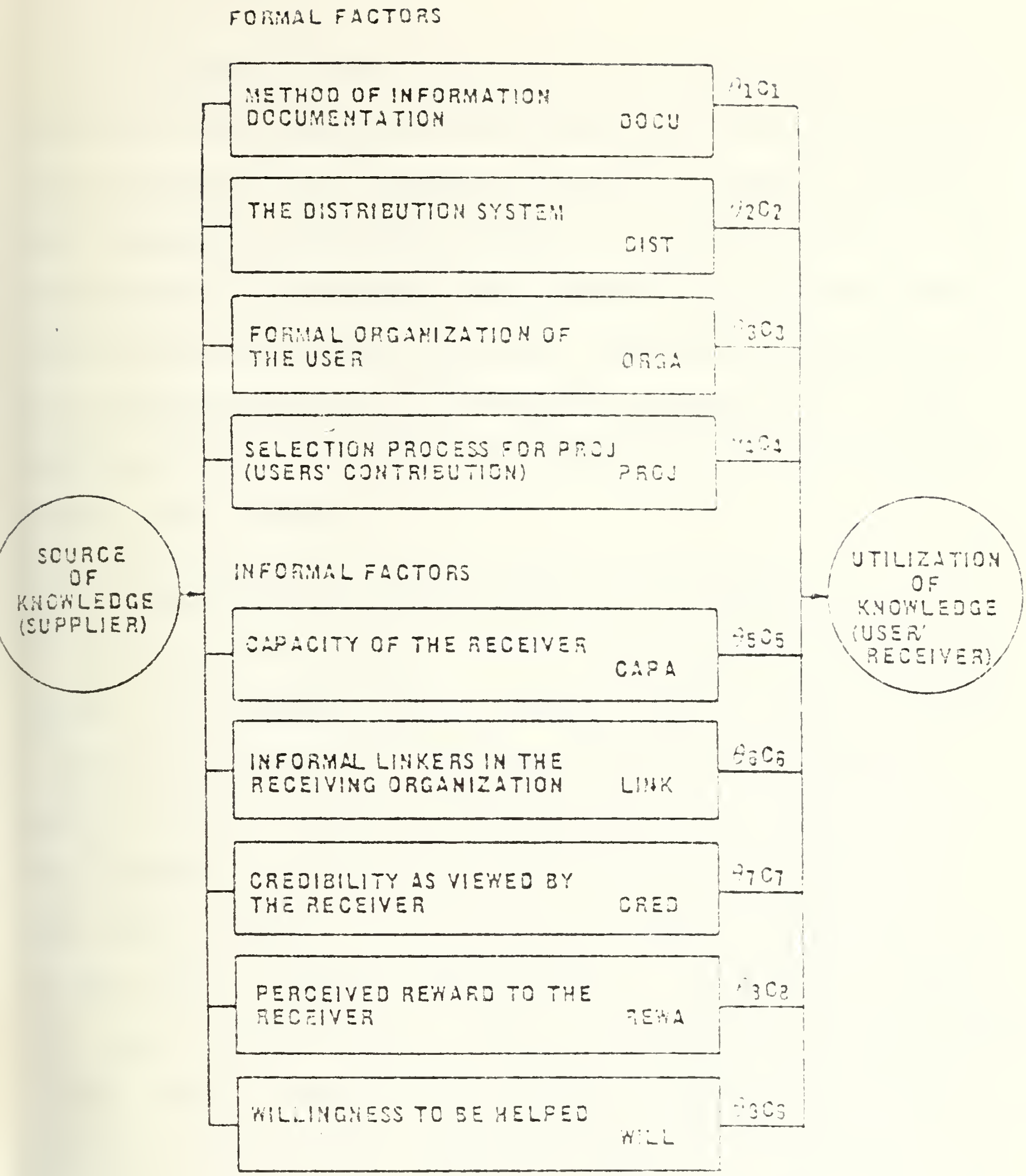
In the introduction to this thesis technology transfer was defined as the process of stimulating or helping someone other than a research supporter to use the results of that research. This process appears to the casual observer to be a relatively straightforward one, but in actual practice it is complicated by a plethora of constraints which are an intimidation to even the most conscientious planner/manager. These constraints can be typified as financial, institutional, managerial, technological, informational and motivational. However investigation of the technology transfer process by academic researchers demonstrates that: [21:60]

> (a)n organization apparently does not need to expend considerable resources or rely upon outside agencies to stay in touch with the rest of the technical community. Usually, there are people within their own organizations who have the ability and inclination to perform this task. The challenge for a concerned management is to

provide a favorable work environment for the self-motivated individuals who want to learn about needed new ideas and methods and who will promote their adoption by others.

One conceptual model of the transfer process has identified several factors which when taken individually are theoretically measurable and when taken in combination are theoretically predictive of the efficiency level at which the utilization of technology occurs in an organization. This model was first utilized in research by Creighton, Jolly, and Denning in 1972 and is known as the "Technology Transfer Process Model" (TTPM). [4] The TTPM represents a distillation of many other models of the transfer process. At present, research is being conducted to validate each of the elements of the model and to develop weighting values for the coefficients which mathematically represent each element. Figure 1 depicts the TTPM.

The nine transfer factors of the model have been divided into four "formal factors" and five "informal factors." The formal factors are "more tangible, objectively measurable, and subject to external control" than the other factors. [22:4] These formal factors are very important to the decision-makers in the user organization because the way these factors are implemented determines whether they "will be an aid or barrier to the transfer process." [22:4] Describing the formal factors as "externalities" also imparts an appreciation for the nature of their relationship to the user. These externalities impinge upon the users ability to adopt a new technology because they represent procedural restrictions upon independent actions.



THE MODEL MAY BE EXPRESSED IN EQUATION FORM SUCH THAT:

$$L_i = \sum \theta_1 C_1 + \theta_2 C_2 + \ldots \theta_j C_k$$

WHERE

L_i = LINKER INDEX FOR AN ORGANIZATION i

θ_j = A MEASURE OF FACTOR UTILIZATION, θ_j RANGE 0 – 1

C_k = A MEASURE OF THE FACTOR CONTRIBUTION, $\sum C_k = 1$

FIGURE 1
[23:24]
PREDICTIVE MODEL OF TECHNOLOGY TRANSFER

The informal factors include "individual traits, capabilities, perceptions and predispositions which are especially pertinent to a technology transfer effort." [22:9] They represent behavioral and/or sociological facets of the individuals who determine the success of a transfer effort. The principle utility of the TTPM lies in its awakening of the planner/manager to the resources available for implementing technology transfer both internally and externally to the organization.

C. A DESCRIPTION OF THE ELEMENTS OF THE TTPM

As depicted in Figure 1 there is a veritable phalanx of formal and informal factors through which information from a source must pass to "ultimately arrive on a decision-maker's desk." As each of these factors are addressed in the following sections the reader is invited to keep in mind the mechanisms of technology transfer previously described for the Federal establishment. The Federal Government can represent both a source and a discrete organization in this model. Many of the Federal mechanisms represent practical, real world manifestations of the academic concepts herein proffered and are directly applicable in most instances to any organization.

1. <u>Documentation</u> (DOCU)

"This is the format, specifications, and presentation of the technology, or information being transferred." [22:5] Inherent in the documentation factor is language. Acronyms, jargon, specialized argots and general lack of

clarity all contribute to increasing the difficulty of comprehending someone else's "obviously useful" discovery. The format of the information being presented often determines who will be the user groups. Many scientists prefer abstracts for finding information and reviews for keeping current in their field of study. [22:5] Reviews are time consuming to prepare however and oftentimes the publishing lag-time makes their technical information obsolete. "Refining, packaging, and selling technology should receive more attention." [22:5] The Federal Government's efforts in this area are concerned with the tailoring of research documents to specifically targeted user groups. The Information Analysis Centers (IAC's) are a particular Federal effort to address documentation problems and to secure a higher degree of utilization of technical information by recipients.

2. <u>Distribution</u> (DIST)

"This factor is the physical channel through which technology flows, involving both the number of entries and ease of access into the channel, as well as the formal distribution plan as it impacts on the information user." [22:5] Distribution can take the form of everything from sophisticated computerized data bases with remote access and real time interactive capability to a quiet conversation over a cup of coffee in the company lounge. As the Federal Government has discovered, the mere dissemination of information is not enough to induce utilization. Elaborate printed and electronic distribution mechanisms

in and of themselves do not guarantee that a transfer will occur. As one researcher stated: [22:6]

> All the possible ways of classifying content cannot possibly be taken into account in the organization of journals, in the indexing and abstracting services, or even in the selection of the title of papers. Any given researcher must depend largely on friends who work in adjoining specialities, yet know what is of interest to him, to point out the pertinent material to him.

3. Organization (ORGA)

"This is the impact that the formal organization of the potential technology user has upon a transfer effort." [22:6] There are many different facets of the effects which the strategy, structure and process of an organization has upon its receptivity to the transfer of technology. The alternative ways in which organizations define their product-market domains (strategy) and construct mechanisms (structures and processes) to pursue these strategies is complex and changeable. An example given earlier in this paper; that of the technological "Prospector," illustrates this crucial interplay with the environment. Other elements also define the impact of the organization upon the prediliction of its members to pursue new technology. One of these is the degree of awareness by the organization's members of the organization's needs, problems and opportunities. This needs-pull phenomenon has been recognized in the Federal Government and addressed to by such mechanisms as the promulgation of OMB Circular A-109, the formation of the OSTP and Congressional Committee actions. Many ideas are stimulated when validated needs are promulgated and understood by all members.

Another element is the organizational imperative to remain in existence. An effect of this imperative can be felt in the form of "proprietary" information and the desire for organizational stability and continuity. The experssion: "...thats the way we do business, take it or leave it" nicely illustrates an organization's efforts to "achieve its objectives and to maintain its society, structure, functions, values, language, and style of operation." [22:7] These tendencies can lead to the obstruction of change and innovativeness. Grubber recognized that change "...is the way of life. The only way that successful change can take place is to overcome the resistance to it and provide the proper organizational conditions to enhance it." [23:30]

The key to overcoming resistance lies in the climate within which informal groups are tolerated in an organization. Research has shown a "significant correlation between informal intergroup climate and an organization's problem solving ability and communications problems." [22:7] Even such seemingly mundane aspects of the organization as geographical location of key organizational members, the functional structure of the organization and the design of the organization's physical facilities can impinge upon effectiveness. [22:7] The use of project teams and matrix organizations are attempts at reducing organizational rigidity. Placing decision makers closer to end-users also enhances technology transfer. Federal sector demonstration projects are examples of an

organizational structure which aids in converting uncertainty to risk for both the user and supplier thereby promoting the utilization of a new concept.

A final example of the effect of organizational structure on technology transfer is given by the management of the Federal R&D effort itself. As noted, it is comprised of hundreds of installations sponsored by agencies with linear organizational relationships to their client groups. "Picket fence federalism" does not encourage cross-agency program relationships and impedes inter-agency utilization of R&D outputs.

4. <u>Project</u> (PROJ)

"This factor refers to the selection process for research development undertaken by the source and the reciever's contributions to the process." [22:7] Including the user in the conceptual phase of development was delineated earlier in this paper as an output of Federal Government's recognition that a primary factor in ensuring the conversion of a given technology to a useful product is the extent of "the technical community's awareness of the user community's needs and desires." Development of the awareness of user needs is accomplished in the Federal sector by:

1) field organizations and direct assistance,
2) special survey's
3) special Federal/user mechanisms,
4) tailored documents, seminars, and workshops, and;
5) training and personnel programs.

Therefore, the importance of user input to the R&D facility, or knowledge source, appears important, regardless of the stage of development of the needed technology. [22:8]

5. Capacity (CAPA)

"This factor refers to the ability and capability of the potential user to utilize new and/or innovative ideas." [22:9] A primary determinant of capacity is the level of innovativeness of an individual or work group and of those key players and groups in an organization which are attempting to adopt a new technology. Innovativeness is defined as "...the degree to which an individual is relatively earlier to adopt new ideas than the other members of his social system." [22:9] In the TTPM the capicity factor has been measured via socio-psychological testing which has been designed to determine the attributes of innovativeness. "Thus, by isolating socio-psychological attitudes of innovators as a group in general, one can predict whether a specific potential user has the capacity for innovativeness and, consequently, the ability to adopt a new technology." [22:9]

Independent studies by Rogers, Robertson and Loy established statistically valid attributes of innovators that can be used to predict innovative behavior. [22:9] Loy established six attributes (venturesomeness, professional status, imaginativeness, educational status, dominance, sociability and cosmopolitaness) which differentiated innovators from non-innovators.

6. Linker (LINK)

"This refers to the presence of, and effects of, individuals in the receiving organizations who link or couple their organizations to the larger environment". [22:9] Many terms have been utilized to characterize the linker attribute. It is most closely associated with the innovator/adopter discussed in the previous section. The linking role is "taking initiative on one's own behalf to seek out scientific knowledge and derive useful knowledge therefrom. [23:77] A definition of a linker is "an individual who through his own initiation seeks out scientific knowledge, is an early knower of innovation, and acts as an intermediary between the source of knowledge and the individual's organization who put it into use." [23:77]

Linkers can be found residing in the supplier, user or an independent third party organization. An example in the Federal sector is the laboratory representatives of the Federal Laboratory Consortium for Technology Transfer. However this paper stresses the importance of the linker within the user organization. A linker tends toward the following characteristics: [23:53]

- He is an early knower of an innovation or technical advancement pertinent to the organization.

- He is more cosmopolitan, with an orientation more external to his particular organizational system than late adopters. His contacts and interests extend farther than a limited local environment.

- He can be expected to attend more conventions, belong to special groups, and participate in a wider network of interpersonal contacts.

• He has greater knowledge of who innovators are in their fields.

• Linkers as a rule also have more exposure to mass media (journals, magazines, etc.) than late knowers of innovations.

The studies based on the linker concept have demonstrated that linkers can be identified in an organization with a high degree of probability. [21:60, 23:116] This identification is accomplished through a test instrument called the Professional Preference Census.

7. Credibility (CRED)

"Credibility is the receiver's assessment of the reliability of the information before him. It is evaluated as a factor in the model by analyzing both the source and channel of the message." [22:10] As every newscaster, pollster and politician will testify, the manner in which a person reacts to information and makes the decision to adopt it into his organization is measurably dependent upon the credibility he attaches to the bearer of the message and the originator of the message. Physical, social and psychological traits of the person originating or delivering information can influence another persons attitude or opinion. One study demonstrated that: "Communicators were found to be able to influence attitude change...without specifically communicating persuasive arguments and conclusions." [22:11]

8. Reward (REWA)

"Reward is the perceived and actual recognition of innovative behavior in the social system to which the

individual is a member." [22:6] Each member of an organization expects to receive both intrinsic and extrinsic reward for the work he performs. Intrinsic rewards are the "opportunity to use skills, to gain new knowledge, to deal with challenging problems, and to have freedom to follow up one's own ideas." [22:11] Extrinsic rewards can be "a good salary, higher administrative authority, [and] association with top executives." [22:11] Grubber suggests that effective extrinsic rewards for innovative behavior include actions through ratings, inhouse publications, awards by professional societies and allocation points towards promotion. [22:11] Intrinsic motivation has been found to increase with verbal reinforcement and positive feedback in a problem-solving activity and when there is recognition by colleagues. [22:11]

9. Willingness (WILL)

The final factor in this model "relates to the individual's ability and/or desire to accept change in the organization of which one is a member." [22:11] A well known example of this characteristic is the "N.I.H. (not invented here) syndrome." One study demonstrated "that organizations were much more willing to take advantage of NASA technology if there was only minimal disturbance to their industrial equilibrium." [22:12] Willingness "...to face the price of innovation is a major part of the problem of technological progress." [22:12] A manager should be aware that although a new idea may be accepted, the willingness of an individual to actually incorporate the idea into his or her thinking is somewhat problematic.

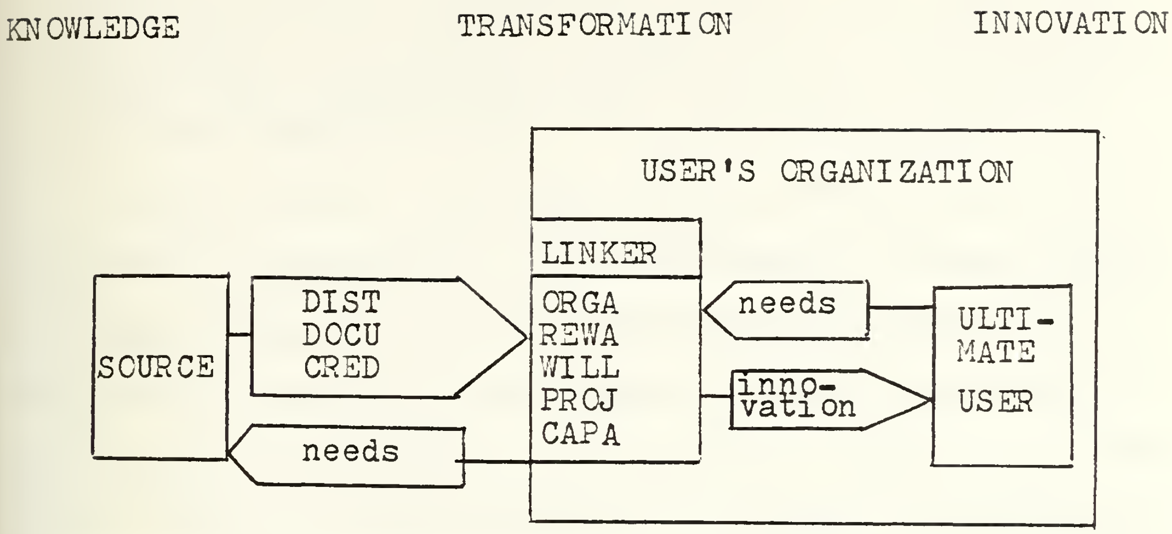


Figure 2. Linker Model for Technology Transfer [21:60]

D. IMPLICATIONS OF THE TTPM FOR THE MANAGER

The formal and informal factors just described provide the manager with a basis for assessing the flow of information concerning technology within its own organization. Figure 2 depicts the critical role of the linker (LINK) factor in the technology transfer process. As previously stated a self-designating test instrument called the "Professional Preference Census" (PPC) has been developed and shown to be a reliable indicator of those personnel with linker characteristics. Another output of this test is the identification of those persons with characteristics opposite to those of the linker. These persons have been identified as Stabilizers. As noted by the developers of the linker model: [21:57]

> No moral distinction should be made between these types, but rather the manager must understand the role each

serves and develop appropriate programs to promote the constructive portions of each of their characteristics... some persons are linkers - others are not. Realization of this fact alone is extremely important and carries countless ramifications.

Linkers provide the bridge between users of innovative information and sources of that information through person-to-person contact. The TTPM delineates the other factors which will impact upon the linker's effectiveness and the information utilization efficiency of an organization. The linker occupies a key position in the channel of knowledge transmittal as indicated in Figure 2. The identification of persons with linker characteristics within the user organization is a crucial task of management because of the high potential returns for a small investment of managerial time. As George et al has noted: [21:59]

> Management must select, sponsor, and properly position within the organization those who have the capacity or ability to innovate and apply progressive information. It must give those individuals latitude in the selection of sources as various projects progress. Identification of linker types is obviously only a step in the promotion of technology transfer. Proper utilization of this resource requires deliberate multi-factored policy that must be supported by an organization's top management.

Linkers, like leaders, can be developed through "properly directed training and education in the dynamics of technology transfer." [21:59] The military forces of countries throughout the world have developed courses to teach leadership and management to personnel identified as potential leaders. An enlightened management can do the same for their technically trained personnel.

E. SUMMARY

Innovation, adoption, linkage - these are words vital to the vocabulary of a manager operating in the complex, capital-intensive organizations of today. Technology transfer is a part of the larger process of technological innovation. Innovation is the process that is utilized to adapt to or harness change. Innovation is a deliberate, planned change to improve a system or accomplish an objective. [23:8] Innovation is based on a systematic, organized leap into the unknown. It utilizes scientific tools but it is a process of the imagination. Technology and Technology Transfer are tools of innovation that are used to help bring about a change. [24:68] Figure 3 is an illustration of the process of technical innovation.

The encouragement of innovation in an organization can be enhanced by proper management action. The criteria for effective innovation presented in Appendix C are drawn from an analysis of the processes which led to the development of the transistor radio and jet airliners. These criteria are presented as an excellent guideline for examining the potential of an innovation to become a viable product or process in the marketplace.

Technology is a crucial source of prosperity for today's organization. It may be the key to our ability to find ways to turn away from capital-intensive processes which are dependent upon dwindling reserves of fuel, the changing values of the labor force, and less accessible sources

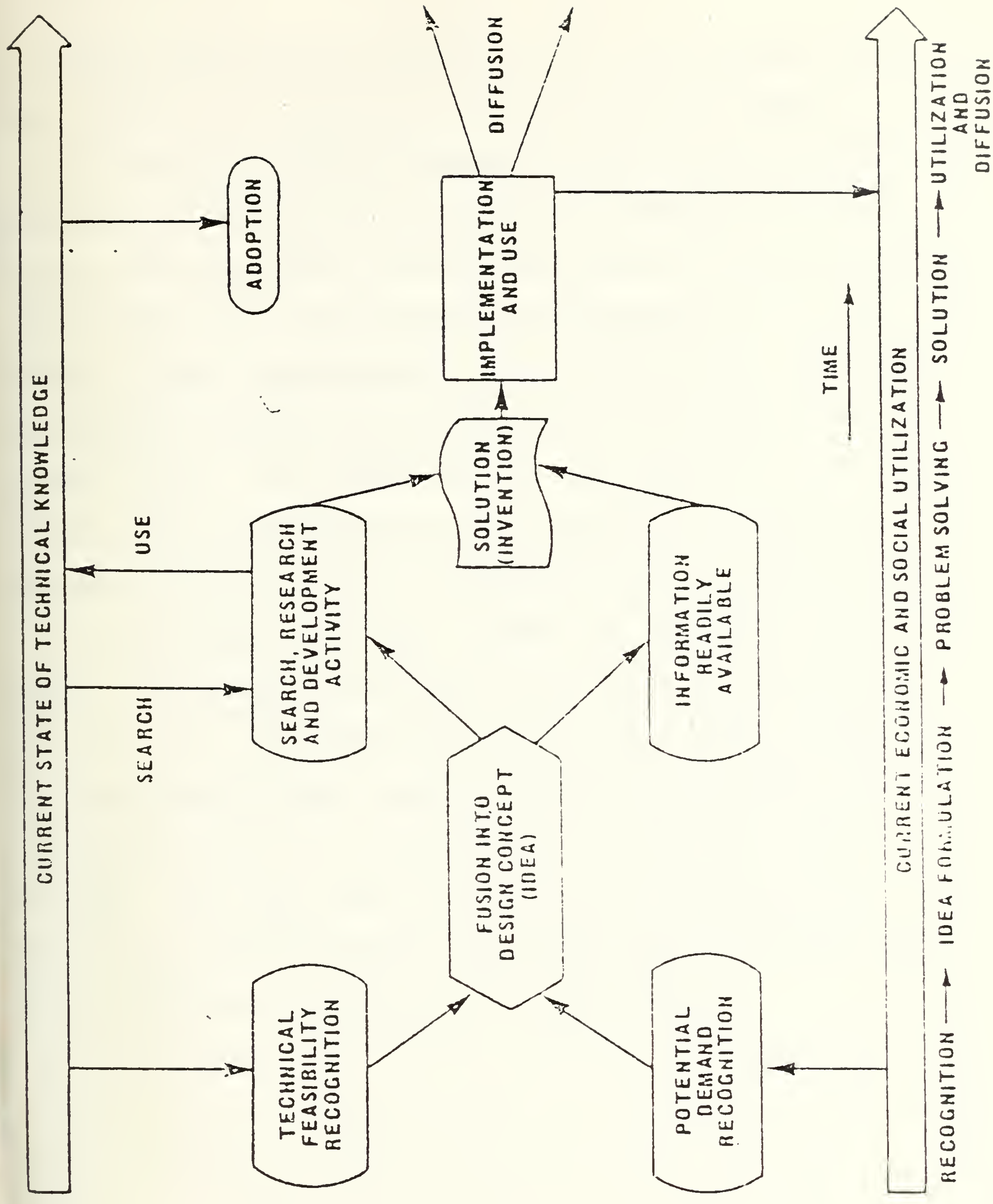


FIGURE 3

THE PROCESS OF TECHNICAL INNOVATION
(SOURCE: MYERS AND MARQUIS, SUCCESSFUL INDUSTRIAL INNOVATIONS, NSF 69-17 p.4)

of capital as inflation tightens up the money supply, and turn towards a new genre of labor-intensive processes.

The extent to which a manager is aware of the diverse alternative technologies around him is largely a function of his or her personal proclivities towards the acquisition of knowledge; and the distribution, documentation, credibility, linker, organization, reward, willingness, project, and capacity factors delineated in the Technology Transfer Process Model. This model (or one very similar) when validated through experimentation will provide an index for assessing the utilization of technology by an organization.

A particularly important element of the model is the linker. The linker represents the human interface which catalogues far more effectively than any present computer the technologies which may be innovative and useful when implemented within the organization in which the linker resides. The linker must be identified, nurtured, and placed in a position within the organization such that his or her ideas can be shared with every member.

IV. A DIFFERENT CONCEPT FOR COMPUTER ASSISTANCE IN THE IDENTIFICATION OF ALTERNATIVE TECHNOLOGIES

A. INTRODUCTION

To this point it has been shown that:

1. The agencies comprising the Federal Government represent a large, fragmented and fertile source of information concerning technology. These agencies utilize diverse mechanisms to promote technology transfer.

2. The linker, rewards, capacity, etc., factors of the TTPM are vital structures and processes for the manager to recognize and manipulate so as to improve his or her access to necessary technical information.

In the description of the TTPM it was made clear that the Federal Government, operating as a very large organization, had created mechanisms which operationalized many elements of the factors defining the technology transfer process.

This relationship illustrates two important objectives of this paper:

1. To provide a large-scale example of the scope and complexity of the technology transfer process.

2. To provide a reference point for the reader who is attempting to characterize the technology transfer environment of his or her own organization.

An adjunct to these objectives is the actual identification of some of the major technology transfer mechanisms of the Federal Government and their availability as a very extensive, real-world data source for both the technical and non-technical manager.

An appropriate departure point for this paper is a discussion of the potential utility of a Decision Support System (DSS) to the manager/planner tasked with improving his ability to identify alternative technologies. This chapter will give an introduction to the principles underlying the conceptual basis for a Decision Support System.

Some examples will be given of the ability of a DSS to act as a management tool capable of linking the outputs of research and development enterprises to decision-makers at all levels of an organization.

B. THE MANAGERIAL POTENTIAL OF A DECISION SUPPORT SYSTEM

The concept of a Decision Support System (DSS) is both nested within and an extension of the Technology Transfer Process Model. It also is an extension of the data bases provided by Management Information Systems (MIS's). In its most basic form a DSS is envisioned as a computer-assisted management tool which allows the manager to "tailor" the strategy, structure and process of his or her own organization to the data processing techniques which can best respond to his or her specific informational needs.

For example, assume that a manager operates within the "Prospector" type of organization as discussed in chapter IIB. The Prospector like any other organizational type, faces three broad "problems" of organizational adaptation. These are defined in the typology of Miles et al as the <u>entreprenurial</u>, <u>engineering</u> and the <u>administrative</u> problems. [11:554] Table 2 depicts the organizational

TABLE 2. Characteristics of the Prospector

Entrepreneurial Problem	Engineering Problem	Administrative Problem
Problem: How to locate and exploit new product and market opportunities.	*Problem.* How to avoid long-term commitments to a single technological process.	*Problem:* How to facilitate and coordinate numerous and diverse operations.
Solutions: 1. Broad and continuously developing domain. 2. Monitors wide range of environmental conditions and events. 3. Creates change in the industry. 4. Growth through product and market development. 5. Growth may occur in spurts.	*Solutions:* 1. Flexible, prototypical technologies. 2. Multiple technologies. 3. Low degree of routinization and mechanization; technology embedded in people.	*Solutions:* 1. Marketing and research and development experts most powerful members of the dominant coalition. 2. Dominant coalition is large, diverse, and transitory; may include an inner circle. 3. Tenure of dominant coalition not always lengthy; key managers may be hired from outside as well as promoted from within. 4. Planning is comprehensive, problem oriented, and cannot be finalized before action is taken. 5. Tendency toward product structure with low division of labor and low degree of formalization. 6. Decentralized control and short-looped horizontal information systems. 7. Complex coordination mechanisms and conflict resolved through integrators. 8. Organizational performance measured against important competitors; reward system favors marketing and research and development.
Costs and Benefits: Product and market innovation protect the organization from a changing environment, but the organization runs the risk of low profitability and overextension of its resources.	*Costs and Benefits:* Technological flexibility permits a rapid response to a changing domain, but the organization cannot develop maximum efficiency in its production and distribution system because of multiple technologies.	*Costs and Benefits:* Administrative system is ideally suited to maintain flexibility and effectiveness but may underutilize and misutilize resources.

Source: Raymond E. Miles and Charles C. Snow, *Organizational Strategy, Structure, and Process* (New York: McGraw-Hill, 1978), Table 4-1.

characteristics of the Prospector and the range of solutions this type of organization typically applies to solve its adaptation problems.

A DSS would employ a logic system which can: 1) input a discrete set of variables that define the characteristics of the organization to which the manager belongs i.e. a Prospector; and 2) output a suggested set of decision support capabilities which would provide the desired information in a format best suited for meeting an unstructured, "what if" type of problem. Conversely, inputing a discrete set of decision support capabilities will output an organizational structure which could best utilize the decision support capabilities.

To illustrate further; Roland suggests that a discrete set of variables which represent an organizational strategy, structure and process might take the form of: [25:15]

- Group (G)
- Environment (E)
- Task (TA)
- Structure (S)
- Individual (I)
- Technology (TE)

These "GETSIT" input/output variables can be expressed as a range of values such that:

G_j, j = 1 to g

E_j, j = 1 to e

TAj,j = 1 to ta

S_j, j = 1 to s;

I_j, j = 1 to i; and

T_j, j = 1 to te.

A "DSS" variable with the form DSS_j, j = 1 to n, is also a part of this structure because of the capability of the system logic to suggest an organizational structure based upon the decision support system employed in the organization.

In words, a DSS might produce the following suggested decision support capabilities in response to a given range of GETSIT variables presented as a managerial problem input: [25:20]

IF Environment is dynamic, and
Task is low cost, and
Task is high priority, and
Structure is consultative

THEN Suggested DSS capabilities include
Individual displays.
Automated message handling,
Real time support, and
Consulting service is recommended

The "IF" portion of the above example has all the characteristics of a Prospector type of input.

This logic method is called a production rule. Production rules are a technique of artificial intelligence (AI) systems. Figure 4 illustrates this interactive exchange more fully.

A DSS employing these production rules has been developed and just for the factors of the TTPM, research is being

PRODUCTION SYSTEM MODEL

VARIABLE	GENERAL CHARACTERISTICS	SPECIFIC (EXAMPLES)
Group	G_j, $j = 1$ to g	G_1 = Formal
Environment	E_j $j = 1$ to e	E_1 = Turbulent
Task	TA_j $j = 1$ to ta	TA_1 = Semi-structured
Structure	S_j, $j = 1$ to s	S_1 = Centralized
Individual	I_j, $j = 1$ to i	I_1 = Skilled
Technology	TE_j, $j = 1$ to te	TE_1 = High
DSS	DSS_j, $j = 1$ to n	DSS_1 = Real-Time
		DSS_2 = Time share
		DSS_3 = Graphics display
		DSS_4 = Not needed
		DSS_5 = Tutorial
		DSS_6 = Individual display
		.
		.
		.

Possible Production Rules:

1. IF G_2, G_3, TA_{12}, S_1, I_{22} AND TE_9
   THEN DSS_2, DSS_6, DSS_{219} AND DSS_{300}.
2. IF E_2, TA_3 AND S_4
   THEN DSS_1 AND DSS_{100}.
3. IF DSS_1, DSS_2, DSS_3, DSS_4 AND DSS_{31}
   THEN G_3, E_4, TA_5, S_6 AND TE_{93}.

Figure 4
[25:21]

pursued to identify the best set of variables to describe the organization and to develop the range of values for each variable. A presently implemented DSS utilizing this conceptual framework is called Decision Aids (DECAIDS) [25:22] Figure 5 represents a conceptual GETSIT-DSS continuum.

The potential utility of this system to the manager is high assuming that the data base from which information will be presented is accurate, current and suited to the needs of the organization. The identification of an alternative technology can be improved because of the linkage provided by the DSS between the MIS data base source and the information transmission channels needed by a particular organizational type to pursue its objectives.

The GETSIT variables are only one possible set of organizational descriptors. Another set of descriptors could easily be the nine factors of the TTPM. Of course the greater the number of descriptors, the greater the requirement for computer assistance to process the increased number of combinations which will occur. The important point of the discussion concerning DSS's is that such a system could simplify and enhance the ability of a manager to identify alternative technologies by acting as an "electronic linker."

Although an electronic linker is not capable of replacing a human linker it can be a supplement to this function. In economic terms the potential for cost-effectiveness is good given the examples of similar systems being developed

GETSIT-DSS Continuum

DSS

- Large Scale computer
- Regular reporting
- Little need for real-time
- No time-share
- Batch orientation
- closed ADP org.
- Single large DB
- Centralized
- single language

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ORGANIZATION VARIABLES

STRONG LARGE	GROUP	NEW WEAK SMALL
STABLE OLD		CHANGING UNSTABLE
STABLE PREDICTABLE	ENVIRONMENT	UNSTABLE DYNAMIC CHANGING UNSTRUCTURED
WELL DEFINED PROGRAMMABLE	TASK	ILL DEFINED VARYING
SIMPLE REPETITIVE		
LINE	STRUCTURE	MATRIX PROJECT
DICTATOR AUTHORITARIAN	INDIVIDUAL	DEMOCRATIC WEAK
INDIVIDUALISTIC LONER		
LOW	TECHNOLOGY	HIGH MULT. TECHNIQUES FRONT LINE
SINGLE TECH i.e. 36/67		

DSS

- multiple types of displays
- Individual or personal terminals
- Multiple sensor data coll. systems
- "What if" ques's
- Mult. data bases
- Decentralized

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.
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Figure 5 [25:18]

and utilized as diagnostic aids to the physician. [25] Certainly time savings could accrue to management by the use of such a system. It seems that many hours of meetings to determine plans and actions for "finding out what is available" could be saved with attendant reduced personnel and even facilities costs. A careful examination of the value of such a system is a very worthwhile goal of any organization.

V. CONCLUSION AND RECOMMENDATIONS

A prime responsibility of managers operating in the highly interdepentent technological milieu of today is to plan for change. A vital facet of this planning process is the identification by management of alternative technologies which may be appropriate to the strategy, structure and process of their own organization. Every manager should recognize the requirement to identify every accessible source or supplier of information.

Once a source is identified the manager must understand the complex nature of the technology transfer process and the factors which define the extent of the process both in and out of his own organization. After uniquely identifying these transfer factors the manager must manipulate them so as to improve both the effectiveness and the efficiency of the transfer process.

The dynamic nature of the entreprenurial, engineering and administrative problems which occur simultaneously in an organization creates such a large number of alternatives for action that computer assistance is indicated for near real-time analysis. A Decision Support System (DSS) extends the utility of a Management Information System (MIS) by using a logic for processing which employs the production rules of artificial intelligence techniques as applied to a set of specifically defined characteristics of a given organization. A DSS, with its ability to link sources to

users via appropriate informational channels, can represent an "alternative technology" for improving the quality of decision making at every level of an organization's management structure.

Specific recommendations for improving the managers ability to identify alternative technologies are as follows:

1. Formalize the management emphasis on innovation, creativity and technology transfer within your organization.

2. Encourage the study of the technology transfer process at all levels of management.

3. Promulgate a formal description of the strategic typology of your organization which elucidates the mission(s) and need(s) of the organization.

4. Identify the linkers within your organization via a Professional Preference Census (PPC) type of examination and distribute these persons to positions where their proclivities would be most beneficial.

5. Encourage the attendance by employees of symposia, workshops, and other special mechanisms which encourage face-to-face involvement.

6. Request from suppliers a clear, comprehensive statement of the capabilities they possess in the area of technology transfer.

7. Develop within your own organization a clear, comprehensive statement of the organizations capabilities in the area of technology transfer.

8. Affect a "technology transfer" from this thesis and utilize the information herein within your <u>own</u> plan for improving your ability to identify the alternative technologies necessary for mid range and long range organizational planning.

APPENDIX A

[ref 3:26-36]

1. The National Technical Information Service

The National Technical Information Service (NTIS) of the Department of Commerce had its origin in 1946, as the Government's instrument for channeling captured German and Japanese research and technology to U.S. industry. At that time it was known as the Office of Technical Services. In the mid 1950's, as Federal government research and development efforts grew very large, the mission was expanded to provide a central public access point for resultant technical reports. NTIS was established in 1970 as an information service organization "for making the results of technical research and development more readily available to industry, business, and the general public by maintaining a clearing house for the collection and dissemination of scientific, technical and engineering information." NTIS undertakes and develops products and programs having the potential for self-support which are appropriate for government instead of private enterprise. The products and services of NTIS are intended to increase the efficiency and effectiveness of the U.S. research and development enterprise. NTIS receives only minor support through Congressional appropriation, it recovers about 90 percent

f its costs from the sale of its products and services, very much like a usiness.

NTIS is the central Federal source of U.S. and foreign government sponsored research, development and engineering reports and other nalyses prepared by Federal, state and local government agencies, neir contractors or grantees, and by Special Technology Groups. Federal agencies are required to submit such unclassified reports. Other rganizations, numbering in the hundreds, provide them through agreeents with NTIS. NTIS is also a central source for Federally generated achine processable data files and manages the Federal Software Exchange enter. The NTIS information collection includes over one million re-earch report titles, about 150,000 of which are of foreign origin and me 500,000 resulting from Federally sponsored research from 1964 to 77. About 70,000 new reports are added annually. NTIS is the only ntral source of research reports and other analyses that are developed the vast Federal network of departments, bureaus, and agencies.

All reports received by NTIS are indexed, abstracted, and nounced to the public through a variety of publications. It should be membered that the user must request and pay for these publications. e basic NTIS announcement vehicle is a series of newsletters entitled eekly Government Abstracts. These abstracts provide 100,000 readers th summaries of research reports and other specialized information thin two weeks of receipt by NTIS from the originating agencies. These stracts provide maximum coverage in brief and convenient form at

minimal cost. Presently there are 26 subject areas in the series. New subject categories are added when subscribers' requirements are sufficient to justify a new bulletin and allow for recovery of production costs. The Weekly Government Abstracts published now are Administration, Agriculture and Food, Behavior and Society, Biomedical Technology and Engineering, Building Technology, Business and Economics, Chemistry, Civil Engineering, Communication, Computers, Control and Information Theory, Electrotechnology, Energy, Environmental Pollution and Control, Government Inventions for Licensing, Health Planning, Industrial and Mechanical Engineering, Library and Information Sciences, Material Sciences, Medicine and Biology, Natural Resources and Earth Sciences, NASA Earth Resources Survey Program, Ocean Technology and Engineering, Physics, Problem-Solving Information for State and Local Governments, Transportation, and Urban Technology.

In addition to published bulletins and announcements, descriptions of reports are stored in computer data base for retrieval on a customized basis to satisfy a very specific user information need and on a more general basis for anticipated users' needs.

NTIS distributes about 20,000 information products daily, making it one of the world's leading processors of specialty information. It ships its customers about four million documents and microforms annually. Some other subscription items offered by NTIS are Tech Notes (summaries of new applications for technology as developed by nine Federal agencies and their contractors). Research Reports, Aerospace

Medicine and Biology, Report of Navy Research Laboratory Progress, Foreign Translation from the Joint Publication Research Service, Foreign Broadcast Information Service, Internal Revenue Civil Tax Cases, Aircraft Accident Reports, Census Reports and Patent Subscription Service (more will be said about Federal government patents and NTIS in a later section).

The NTIS collection is the largest and best publically available pool of widely varied research results in the world. The best way for a potential user of NTIS information services to find out how NTIS can help him or his organization is to contact NTIS personally.

2. Smithsonian Science Information Exchange

The Smithsonian Science Information Exchange (SSIE) was established in 1949, then called the Medical Science Information Exchange, by six Federal agencies engaged in the support of research in the medical science. It is now operated as a nonprofit corporation by the Smithsonian Institution. The SSIE assists in the planning and performance of research activities by providing up-to-date information about research in progress. The Exchange is the major national source for unclassified information on current and recently completed research in all fields of science, with emphasis on interdisciplinary relationships. The SSIE's active file contains information on 200,000 current and recently completed research projects collected during the last two fiscal

years. The current file contains 20,000 research projects in all areas of social sciences research. Approximately 60 percent of the projects on file are in the life sciences and 40 percent in the physical sciences. New projects are added daily and projects continuing over a number of years are updated annually. The SSIE compliments other scientific and technical information services. By supplying information on ongoing research, the critical gap between the start of a research project and the time its results are published is bridged. This time period is often measured in years.

More than 1,300 supporting organizations provide SSIE with timely project descriptions of high scientific quality. Research project information, normally registered at the time work is funded, is supplied by virtually all Federal agencies engaged in basic and applied research, state and local governments, nonprofit organizations, universities and colleges, and, to a more limited extent, individual investigators, private industry, and foreign research organizations. Approximately 80 percent of the information is supplied by Federal government agencies, from both in-house and out-house research.

Information received by SSIE is classified, indexed, and stored in computers in such a manner so as to provide the flexibility to retrieve project information in the variety of forms desired by its users'. The SSIE itself engages in research designed to improve methods for indexing, storage and retrieval of information about ongoing research.

The basic record in the SSIE system is the single-page Notice of Research Project (NRP). The NRP contains the following information about each project: project title, supporting organization name and project number, performing organization name and address, Name(s) of the investigator(s), period covered, level of funding, and a 200-word technical summary of the work to be performed. This information provides the user with an effective means for follow-up and an opportunity to expedite the exchange of more detailed information about problems encountered or preliminary results.

Some of the reasons individual investigators and research managers use SSIE are to:

1. avoid costly, unwarranted duplication of research effort and expenditure;
2. identify possible sources of support for research on a specific topic;
3. obtain leads to the published literature, unpublished monographs, participants for symposia, and the like;
4. identify information to support grant or contract proposals;
5. stimulate new ideas for research planning in experimental methods;
6. acquire data for use in technological forecasting and development;
7. survey broad areas of research to identify trends and patterns or to reveal gaps in overall efforts;

8. learn about the current work of a specific investigator or organization.

SSIE search services are provided only upon request and they are priced to cover costs. Among these services are:

1. Custom Search, search of the active file for NRP's on specific subjects by performing organizations, specific geographic area, or some similar criterion.
2. Research Information Packages, results of SSIE conducted searches of the active file on subjects of high current interest.
3. SSIE Science Newsletter, contains newest research information package titles plus articles of interest to the scientific community. Available on subscription.
4. Selective Dissemination of Information, regular updates of custom searches or research information packages. Available on subscription.

Other services include On-Line Search Service, Investigator Searches, and Historical Searches.

Searches may be ordered in person or by letter, telephone, or cable.

3. <u>National Referral Center</u>

The National Referral Center (NRC) is a referral service that directs those who have questions concerning <u>any</u> subject to organizations, groups, services, libraries, centers, or individuals from which or

from whom authoritative information is available. The NRC is located in the Library of Congress and it is a function of the Science and Technology Division. Operation of the center is financed by funds appropriated by Congress; therefore, the services of the NRC are free, except that its publications are sold by the Superintendent of Documents, Government Printing Office.

The NRC has three basic tasks:

1. inventory all significant U.S. information resources in specialized fields, including both the "for profit" and "not for profit" elements;
2. provide any individual or organization, on request, with information regarding these resources;
3. compile and publish directories and other listings of information resources.

The referral center does not furnish answers to specific questions or provide bibliographic assistance (the center does furnish titles of abstract journals, indexes, and directories when they are particularly relevant to the inquiry). Instead, it directs those who have questions to resources that have the information and are willing to share it with others.

The NRC presently has a subject-indexed, computerized file of 13,000 organizations and individuals that make up the center's "information resources." The file description of each resource includes its special fields of interest and the types of information service it provides.

The NRC file is maintained by professional analysts and is used primarily by the center's referral specialists. This computerized file is available through computer terminals located in some Library of Congress reading rooms and to many Federal agencies nationwide through a Department of Energy computer network called RECON.

The NRC actively seeks out and invites organizations and individuals that have information in specialized fields to participate as information resources. The criterion for registering an organization is not size but ability and willingness to provide information to others on a reasonable basis.

Requests for referral services are made by letter, telephone, or in person. The NRC encourages requests by telephone or in person to allow for discussion and refinement of complex questions. The center will accept requests on any topic. If a subject is not covered in the data file, the center will attempt to locate new information resources.

The reply to a referral services request is usually in the form of a computer printout and it contains the names, addresses, telephone numbers, and brief descriptions of appropriate information resources. In each case, the response is individually tailored to the specific request.

The NRC makes a sharp distinction between referral and reference activities.

> "The center's purpose is not to duplicate what libraries and information centers are already doing and are organized and equipped to do; it hopes to go beyond that both in variety and specificity - to make ever more

precise linkages between the user and the place where the highly specialized information that the user requires is to be found."

The NRC tries to establish the most direct contact possible between people looking for information and those who can provide it.

Occasionally the NRC compiles directories of information resources covering a broad area; Water, General Toxicology, Social Sciences, Biological Sciences, and Physical Sciences, Engineering are examples. These are published by the Library of Congress under the general title A Directory of Information Resources in the United States with subtitles as listed above. These may be purchased from the Superintendent of Documents, U.S. Government Printing Office.

The NRC also issues informal lists of resources that have information on specific topics, such as population, environmental education and hazardous materials. These are available free of charge from the center for as long as they last.

In 1974 the head of the Science and Technology Division, Library of Congress said the following about NRC publications:

> "Publications should not be overemphasized; they are not really paramount. The center heartily subscribes to the conviction that scientific and technical information is most effectively transferred from person to person, not from media to people. NRC is therefore most concerned with putting people in touch with people, with the communication of facts and ideas directly from one human mind to another."

The NRC continually evaluates its services by follow-up letters. It has determined that users receive the information they need about 82 percent of the time.

A good analogy for the National Referral Center is to think of it as a kind of technical equivalent of the telephone directory's "yellow pages," directing inquiries to reliable, expert information on particular topics.

APPENDIX B

[ref : 53-62]

GOVERNMENT PATENT POLICY AND FEDERAL RESEARCH AND DEVELOPMENT

1. Federal Laboratories

There is no doubt that patent rights in inventions resulting from Federally funded research and development conducted in Federal laboratories and research centers belong to the government. The evaluation of government patents for commercialization and secondary utilization and the methods to achieve those ends will be presented later.

Inventions that originate in civil-mission laboratories will usually have direct civilian application due to the type of research and development that these laboratories undertake. They may also have secondary utilization potential.

Inventions that originate in special-mission laboratories are almost never in a form so that they may be transferred directly to the marketplace and usefully applied. There is almost always a need for product modification. This usually involves considerable technical and financial risk. Special-mission laboratories are very seldom funded for such effort simply because it is not seen as part of their mission, and the laboratories often do not desire to do such work for fear it will dilute their special-mission efforts.

2. Federally Funded Private Sector Research and Development Contracts

For over thirty years there has been a controversy over what the Federal government's policy should be with respect to patent rights in inventions resulting from Federally funded research and development contracts with private sector organizations, profit and nonprofit. Presently there is no general legislation that controls all Federal agencies in the disposition of rights to such inventions. Federal agencies have widely varying policies with regard to taking title to patentable inventions made under such contracts; however, these can be generally grouped under two policies, the so-called "title" and "license" policies. Under the "title" policy the government takes title to the rights in these inventions (i.e., patents) and then allows private interests to utilize the inventions through licensing. Under this policy the government may choose not to patent the invention, but to publish it instead and thereby

make it available to anyone and everyone. The "title" viewpoint is basically that any inventions which result from Federally funded research and development should be the property of the government. To give companies the rights to such inventions is in effect a double charge on the public: first for the research and then for the monopoly profits resulting from such "giveaways." Under the "license" policy the contractor is given title to the rights in the inventions, with a royalty-free license retained by the government; however, there is no obligation on the part of the contractor to let other qualified applicants have access to the products of government funded research. The "license" viewpoint is that the public will best be served by this type contract because the most qualified contractors will compete for the contracts and because private industry is best equipped for developing and promoting such inventions. Whatever the policy, it must be delineated in the contract in the form of a patent clause.

In 1963 President Kennedy issued a Statement of Government Patent Policy which took the position that one single patent policy was not appropriate, a more flexible policy was required. This statement took a middle ground approach to the "title" and "license" policies and described in <u>general</u> terms those conditions under which the government would take title and those under which it would only take license. A 1971 presidential statement on the same topic, a slightly modified version of the 1963 statement, now guides Federal patent policy with

respect to the disposition of rights to inventions made under Government sponsored contracts and is implemented by the regulations of various agencies. This statement recognizes the inventions in scientific and technological fields resulting from such contracts as a valuable national resource and states that;

> "The public interest in a dynamic and efficient economy requires that efforts be made to encourage the expeditious development and civilian use of these inventions. Both the need for incentives to draw forth private initiatives to this end, and the need to promote healthy competition in industry must be weighed in the disposition of patent rights under Government contracts."

The position is that the ownership of inventions resulting from research and development contracts cannot be determined in advance by an arbitrary or fixed rule but must be decided in each instance in accordance with the facts involved.

The patent policy with respect to inventions developed under government contracts requires the responsible officials in the numerous Federal government agencies involved to interpret the general policy and to make many judgemental decisions. In each instance the ultimate criterion to be used is "what would best serve the public interest?" Given the complexity of the situation and the latitude that exists, it should not be surprising to find the widely varying policies that are in effect.

Considering the fact that over half of the Federal government's research and development effort, $26 billion in 1978, is contracted out

to private industry, the "stake" that the public has in resulting inventions is not insignificant.

3. Government Patents

Federal laboratory employees are required by law to report fully any new technology they develop in the course of their work. Contractors doing research and development for the Federal government are required by their contracts to do the same. The reason for this requirement is so that the new technologies can be evaluated for further government applications, patenting, adaptation for secondary utilization, and commercialization. The main objective is to achieve optimum technology utilization. A secondary reason, which actually results in more government patents, is to protect the Federal government from future claims for royalty payments.

In Federal agencies, especially special-mission type, the motivation to report and export for commercial consumption the technology developed in support of public policy and projects is lacking. The primary urge of these scientists, once a project is completed, is to "get on with the next one." In addition, the bureaucratic, red tape, paper work shuffle that the inventor must go through to report an invention (an invention he very often considers trivial and insignificant) is a demotivating factor

All Federal agencies that sponsor research and development have a procedure by which they evaluate new inventions developed.

These procedures vary between agencies. It is up to the individual agencies how they will publish and promote those inventions which are evaluated as having potential for wider use, secondary utilization and/or commercialization. An invention may be made generally available by publication, known as dedication, or it may be made available through licensing after being patented. Each agency patents its own inventions. Licensing may be exclusive or nonexclusive and royalty bearing or royalty free. Whatever the method, the rational is that Federal government inventions normally will best serve the public interest when they are developed to the point of practical application and made available to the public in the shortest possible time so as to assist in the accomplishment of the national objective to achieve a dynamic and efficient economy

When an invention is patented, the granting of a nonexclusive license is generally preferable since the invention is thereby laid open to all interested parties and serves to promote competition in industry. However, to obtain commercial utilization of an invention, it may be necessary to grant an exclusive license for a limited period of time, normally not to exceed five years, as an incentive for the investment of risk capital to achieve practical application. Whenever an exclusive license is deemed appropriate, it must be negotiated on terms and conditions most favorable to the public interest and only after:

1. The invention has been published in the Federal Register, the Official Gazette of the U.S. Patent Office, and at least one other publication, as being available for nonexclusive licensing for a period of at least six months;
2. it has been determined that the invention may be brought to the point of practical application by exclusive licensing and that the desired practical application is not likely to be achieved expeditiously in the public interest under a non-exclusive license or as a result of further Government funded research and development;
3. the notice of the prospective exclusive license has been published for at least 60 days.

Royalty fees are not normally required from licensees because such fees would be passed on to the public in the form of higher prices for resultant products.

An application for nonexclusive license will contain, among other things, a statement of the purpose for which a license is desired, a brief description of the applicant's plan to achieve that purpose, and some indication of how the granting of a license would be in the public interest. In addition, an application for exclusive license will indicate if the applicant is a U.S. citizen, identify any other exclusive licenses or license applications held, and provide a statement of capability to undertake the development and marketing required to achieve the

practical application of the invention and the intention to perform such acts.

> "In selecting an exclusive licensee, consideration shall be given to the capabilities of the prospective licensee to further the technical and market development of the invention, his plan to undertake the development, the projected impact on competition, and the benefits to the Government and the public. Consideration shall be given also to assisting small business and minority business enterprises as well as economically depressed, low income, and labor surplus areas, and whether each or any applicant is a U.S. citizen or corporation."

Licenses are subject to reservations. As a minimum, nonexclusive and exclusive licenses will be revocable and provide for royalty free reservation rights in the invention to the United States Government.

The National Technical Information Service (NTIS) is the central government information source for all government inventions. There are over 28,000 government owned patents. The NTIS has some 16,000 of these patents issued from 1966 through 1974 cataloged and available for licensing. The patents cover all fields of science and technology and many have applications beyond their original design; however, only a small percentage of these have been commercialized or put to wide use.

Since 1972 all government agencies submit their new inventions to NTIS when they file for a patent and again when patents are issued. All these inventions are listed in a weekly NTIS illustrated newsletter entitled Government Inventions for Licensing. All inventions are

evaluated by NTIS and the most commercially promising inventions are summarized in another publication, Selected Technology for Licensing. More than 2,000 government inventions are patented annually by the government and processed by NTIS. On selected inventions, NTIS obtains foreign patent protection to provide U.S. firms with a more attractive licensing package and to insure royalty income from foreign users if no U.S. firms are interested in the foreign markets.

Since NTIS started evaluating government patents for commercial application in the early 1970's, it has continually tried to improve its evaluation system. The quality and quantity of the inventions that are eventually transferred to society is directly related to the level of sophistication of the screening device employed. The initial screening device assumes even greater importance when the cost of commercialization of an invention is compared to the cost of invention itself. As a general rule of thumb, the cost of developing and commercializing a new invention is ten to 100 times as expensive as attaining the invention, and there is no guarantee that the new product will be successful in the marketplace. The NTIS has contracted out a number of studies in an effort to improve its evaluation system and it will very shortly contract out for additional evaluation capability to supplement its in-house capability.

In addition to Department of Commerce inventions, custody of inventions from other departments may be transferred to NTIS for

promotion, foreign filing, and licensing. Where inventions have not been assigned to NTIS, prospective licensees are referred to the appropriate agencies.

NTIS promotes licensing through seminars, exhibits, and direct contact with prospective licensees. Nominal fees and royalties are normally charged to permit NTIS to operate its patent program on a self-sustaining basis.

About one government patent in ten is selected for promotion by NTIS, about one in 100 is selected for "heavy" promotion. In 1976 about 150 government patents were licensed by <u>all</u> Federal agencies out of over 2,000 government patents issued.

Although the number of patents issued should not be considered the sole indicator of research and development effectiveness and efficiency, it is interesting to note that in recent years the proportion of patents issued to the Federal government on a yearly basis was less than five percent of the total number of domestic patents issued

In the same period the Federal government provided about 65 percent of all funds spent on research and development in the United States.

The patenting of inventions that result from Federally funded research and development provides the government with a means for moving technology from the public sector to the private sector.

APPENDIX C

[ref 26:15-22]

Management Criteria for Effective Innovation

Three questions turn out to be crucial in determining the technical potential of any inventive concept:

- What fundamental technical constraints limiting the prior art are lifted?

- What new technical constraints are inherent in the new art?

- How favorable is relief of the former weighed against the stringencies of the later?

The second stage of applying these management criteria is to analyze the embodiment in which the new technology will go to market. Here again the analysis takes the form of answering three questions:

- Is the end product enhanced by additional technology and components required to make use of the innovation?

- Is the inventive concept itself diluted or enhanced by the embodiment required?

- Does the additional embodiment offer opportunity for further inventive enhancement?

The answer to these two sets of questions establish the technical potency of a new innovation, but they offer no criteria in the business context from which to judge such things as profit potential. Three questions are also involved here:

- What previously-emplaced business operations are displaced or weakened by the new innovation?

- What new business operations are needed or wisely provided to support the new innovation?

- How favorable is cessation of the former practices weighed against provision of the latter?

Finally we determine a set of criteria having to do with market dynamics, on the basis of three questions:

- Does the product incorporating the new technology provide enhanced effectiveness in the marketplace serving the final user?

- Does the operation reduce the cost of delivering the product or service?

- Does latent demand expansion or price elasticity expansion determine the characteristics of the new markets?

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